superelevation of 6·4 inches. The maximum superelevation on the South-Western Railway is 6 inches, and it is, of course, altogether impossible to work with any such superelevation as more than 2 feet. It will be understood that the whole of the constraining force required to keep the engine moving in the curve is supplied by the resolved component of the weight of the engine acting parallel to the plane of the radius towards the centre of curvature.

It will be evident, therefore, that superelevation is a remedy of limited efficacy for a serious defect. The centrifugal force at sixty miles per hour (a speed that the evidence of figures shows to have been exceeded, but which we adopt as a convenient standard) would be $\frac{54 \times 88^2}{32 \cdot 2 \times 528}$, or, approximately, $24\frac{1}{2}$ tons (24·597).

The accompanying diagram (Fig. 1) illustrates the resultant of the two opposing forces acting on the engine.

M = centre of gravity of the engine 5 feet above rail-level. The line MQ = the weight of the engine, and MF = the centrifugal force at sixty miles an hour to the same scale. Completing the parallelogram MFRQ, then MR = the resultant of the two forces. Producing MR, it cuts the rail-level at the point H, which is 5·29 inches inside the outer rail; AE is the superelevation. There would only be, therefore,

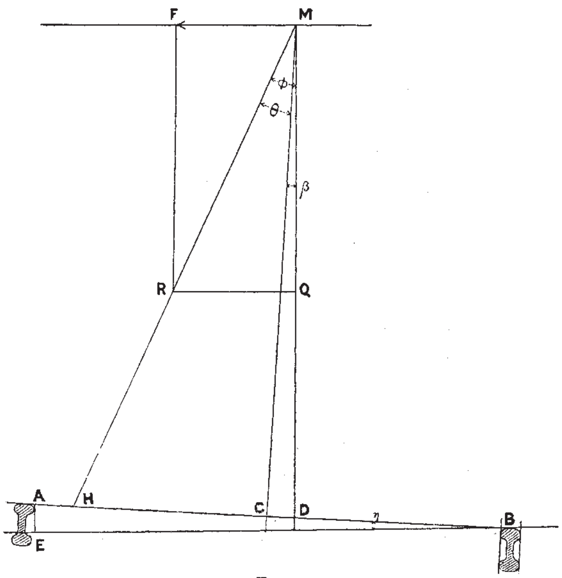

FIG. 1.

about 5 inches between the points A and H. The narrowness of the margin of safety with the data assumed is indicated very clearly in the diagram by the nearness of H to A; should H coincide with A, the engine is just on the point of turning over.

The working out of the problem is as follows:—

MQ = 54 tons.
MF = 24·596 tons.
MC = 60 inches.
AE = 3·5 inches.
AB = 56·5 inches.

$$\tan \phi = \frac{MF}{MQ} = \frac{24 \cdot 596}{54} = 0 \cdot 45548$$

$$\phi = 24^\circ\ 29'$$

$$\text{sine } \beta = \text{sine } \eta = \frac{AE}{AB} = \frac{3 \cdot 5}{56 \cdot 5} = 0 \cdot 0619$$

$$\beta = 3^\circ\ 33'$$

$$\theta = \phi - \beta = 24^\circ\ 29' - 3^\circ\ 33' = 20^\circ\ 56'$$

$$CH = MC \tan \phi = 60 \times 0 \cdot 383 = 23 \text{ (app.)}$$

$$AH = 28 \cdot 25 - 23 = 5\tfrac{1}{4} \text{ inches.}$$

Working backwards with the same data, and assuming the resultant to pass through A, it will be found that the critical speed would be practically sixty-six miles per hour.

In order to calculate CH quickly and with an approximation sufficient for practical purposes, the above working may be very much simplified by the following formula, which has been suggested by Prof. Dalby:—

$CH = h\left(\frac{V^2}{gR} - \frac{e}{G}\right)$, where e = superelevation in inches, G = the gauge in inches, V = the velocity in feet per second, $g = 32 \cdot 2$, R = radius of curve in feet, h = height of centre of gravity of engine above the rail level in feet.

The way in which the formula is obtained from Fig. 1 is as follows:—

$$\beta = \frac{AE}{AB} = \frac{e}{G} \text{ app.}$$

$$\phi = \frac{QR}{MQ} = \frac{WV^2}{gR} \div W = \frac{V^2}{gR} \text{ very approximately.}$$

$$\text{Therefore } \theta = \phi - \beta = \frac{V^2}{gR} - \frac{e}{G} \text{ approximately.}$$

$$\text{Therefore } CH = CM \times (\phi - \beta) = h\left(\frac{V^2}{gR} - \frac{e}{G}\right).$$

The above gives a very nearly correct result when the point H is in the neighbourhood of C, as it should be. The error increases as H approaches A.

We may compare the value of CH obtained by the two methods; we have already shown by the exact method that CH = 23 inches. Applying the approximate formula CH = 23·6 inches.

From the foregoing calculations it would appear that if the train were travelling at a speed of more than sixty-six miles an hour the engine would turn over sideways, but it will be understood that deductions drawn in this way are not proof, though they may be evidence, of what has occurred. The speed of the train is, of course, a very indeterminate quantity; the maximum superelevation was, as stated, $3\frac{1}{2}$ inches, but, to judge by the plan, this did not extend on the curve for a greater distance than about 50 feet, and it would appear that at the spot where the trouble commenced (to judge by the damage to the line) the superelevation was somewhat less. Again, in placing the position of the centre of gravity of the engine, there are various unknown factors which it would be necessary to take into consideration to enable a true result to be reached; for instance, there is the unequal compression of the springs causing lateral displacement of the centre of gravity, rush of water in the boiler, and the extent of wear of wheels and rails.

G. R. DUNELL.

ESTIMATION OF BLOOD-PRESSURE.

THE subject of blood-pressure is one of great interest both to the physiologist and the clinical physician. By blood-pressure is meant the pressure which the blood exerts on the interior of the heart and blood-vessels, but it is chiefly with the vascular blood-pressure—arterial, capillary, and venous—that the physician deals. Our conception of intravascular pressure is facilitated by considering what happens when an aperture is made in an artery, capillary, or vein of a living animal. In the case of the artery the blood squirts out with considerable force, the height of the jet measuring the pressure exerted on the interior of the vessel. Experiment shows that the pressure falls slowly from the heart to the region of the smallest arteries, or arterioles, where there is a considerable fall, the pressure in the capillaries and

veins being comparatively low; in the large veins opening into the right heart it may, indeed, be minus, owing to the suction action of the thorax, and hence when these veins are cut air may actually be sucked into the blood-stream.

The vascular blood-pressure is subject to considerable variation both in health and disease, and it will readily be seen that its accurate estimation is of great clinical value. To take an illustrative case. In certain poisoned states of the blood the small arteries undergo considerable contraction; in consequence of this the blood cannot pass into the capillaries and veins with its wonted facility, and tends to be dammed back upon the large arteries and heart; in other words, the blood-pressure rises in the left ventricle and in the whole arterial tree proximal to the contracted area, and this heightened pressure is further augmented by an increase in the force of the heart-beat, called forth by the necessity to overcome the increased resistance. An increased strain is thus put upon the heart and arteries, and this, if long continued, may lead to disease in them; and in this way such serious affections as aneurism, heart-disease, and apoplexy may be brought about. The importance of early detecting such cases of augmented pressure is apparent, in that it enables steps to be taken to correct the underlying faulty condition of blood, and thus to ward off grave consequences.

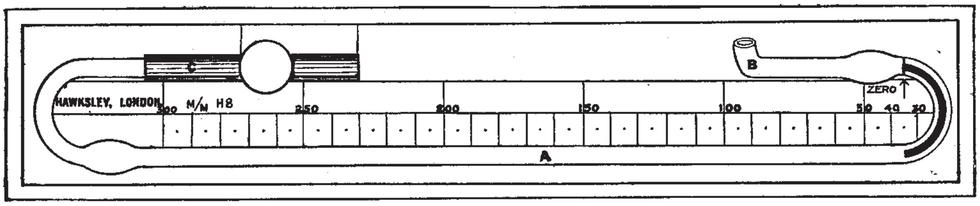

FIG. 1.—Dr. George Oliver's Hæmomanometer (reduced to half size). A is the graduated glass tube along which moves the coloured spirit-index, represented by the dark curved line at the right-hand bend; B is the open end on to which fits the rubber tube communicating with the enveloping bag, or armlet; C is kept closed by means of an air-block, while the blood-pressure is being taken.

Until recently the physician had to be content to rely upon his sense of touch in estimating blood-pressure, and thus it was that the older physicians spoke of a "hard" and a "soft" pulse, the former indicating a high and the latter a low blood-pressure. More modern physicians describe the pulse as "compressible" or "incompressible," or the vessel as being in a state of high or low "tension," according to the readiness with which it yields to the pressure of the finger. This tactile method is, however, far from trustworthy. Not only is long experience needed to acquire even moderate efficiency in it, but from a variety of causes the most skilful are liable to make false estimates by its means; nor do the findings admit of accurate record. In short, though useful as a rough-and-ready method, it lacks the precision needful for scientific observation.

The earliest method of estimating the arterial blood-pressure consisted in cutting the artery of an animal and observing the height to which the blood was forced out. Later the more delicate plan was adopted of connecting the interior of the vessel with a mercurial manometer, by means of an elastic tubing filled with saline solution. Clearly neither of these methods is available for clinical purposes. Recently, however, a method has been devised in which the employment of the knife can be dispensed with, and one, moreover, yielding results quite as accurate as those just referred to. It consists in enveloping some part of the upper extremity—arm, forearm, or finger—in a gutta-percha bag, and connecting the latter, by means of a tubing, with a manometer. The bag is blown up until the pulse on the distal side of it is obliterated, the pressure then registered by the manometer representing the "systolic," or "obliterative" pressure. The "diastolic" pressure, or that obtaining between the heart beats, is measured by noting the excursions of the manometric index produced by the pulsations of the artery; it is held that the maximum movements occur when the pressure on the artery is just sufficient to balance the diastolic pressure.

Hitherto the manometer most frequently used in these observations has been the ordinary mercurial one; but Dr. George Oliver, of Harrogate, has recently devised an instrument which is not only more handy, but would appear to give more accurate readings than the mercurial manometer. It consists of a fine bored glass tube (Figs. 1 and 2) which during use is kept closed at one end, and connected at the other with the enveloping bag by means of elastic tubing. A minute drop of coloured spirit introduced into the glass tube serves as the index. At the commencement of an observation the index is at zero, which is situated at the open end of the tube. As the bag is blown up the index is driven onwards, compressing the air in front of it, and advancing with every increment of pressure. The instrument is readily graduated by means of a mercurial manometer. It will be seen from this description that the

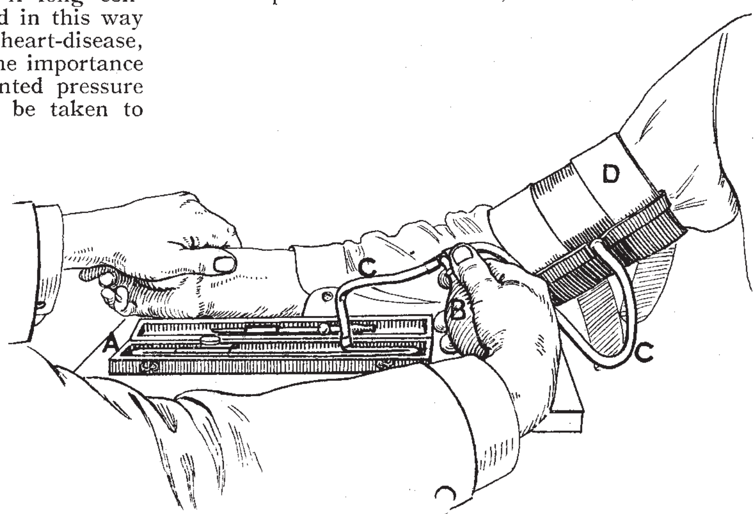

FIG. 2.—Method of employing Dr. Oliver's hæmomanometer. A is the hæmomanometer; D is the armlet; C is the rubber tubing connecting the armlet with the glass tube; B is the rubber ball for inflating the armlet; this is provided with a screw (covered by the thumb), by means of which the armlet and tubing may be gradually deflated.

pressure on either side of the index is equal, a circumstance which tends to reduce to a minimum the errors due to inertia of the index, and this is of great advantage in estimating the diastolic blood-pressure.

In a valuable booklet recently issued by Dr. Oliver[1] on blood-pressure gauging, he sets forth some of the more important results he has arrived at by means of this ingenious instrument. This physician attaches considerable importance to the study of the pressure in the smallest arteries and capillaries by means of a digital bag. He finds that while arteriolar dilatation lowers the pressure in the larger arteries by lessening peripheral resistance, it tends to augment that in the capillaries and pre-capillary vessels by increasing their supply of blood. During muscular exercise, on the other hand, the pressure throughout the entire length of the systemic arteries is increased, owing to the fact that the dilatation of the arterioles is accompanied by a considerable augmentation of cardiac action. The essential circulatory change attending upon digestion, so far as the systemic system is concerned, is, according to Dr. Oliver, an increment in the capillary and pre-capillary pressure, whereby an increase of lymph-exudation is effected, and the products of recently digested food thus speedily conveyed to the tissues. Such an augmentation in the exudation of lymph he claims to have demonstrated.

Of special interest are Dr. Oliver's observations on the blood-pressure of the aged and elderly. With advancing years the smaller vessels tend to become rigid and impervious, and thus to lose their power of dilating in response to physiological requirements, such as digestion and muscular exercise. When this happens the blood-pressure in them is found to be habitually low, and to fail to rise readily during digestion, or as the result of administering such a drug as nitroglycerine, which normally dilates the smaller arteries. In this way the physician is able to gauge the condition of the blood-vessels with a precision which was quite impossible with the older methods. In cases of premature degeneration of the blood-vessels, Dr. Oliver believes that much may be done to check the degenerative process. Among the methods he employs to this end is the administration of certain substances the deficiency of which in blood is thought by some to be largely responsible for the phenomena of senility.

These brief references suffice to show the practical value attaching to the clinical study of blood-pressure. The student in this important branch of investigation will find great help from Dr. Oliver's book, the more so that only salient and practical points are dealt with, and these in clear and simple language.

MENDEL'S CORRESPONDENCE WITH NÄGELI.[2]

THESE letters constitute a valuable addition to the pile of literature that has accumulated under the name of one of the most remarkable figures in the history of biology—Gregor Mendel; for we doubt if ever has so great a fame been built on the contents of a single short paper. The fact that this paper remained unknown from 1865, when it was published, until 1900, when it was rediscovered, is both the measure of how much Mendel was before his time and the reason for the uniqueness of the picture of him which presents itself to the eyes of most of us. We have, it is true, neat and compendious biographies of Mendel, but they reveal to us little of the man himself, and it is still a distant and mysterious monk that appears to us, with his classical peas in his cloister garden. The value of these letters is that they lift the veil for us here and there, and extend to us an invitation to a "private view" of his work, and offer us an opportunity of a nearer acquaintance with its author.

The correspondence was begun by Mendel, who wrote to Nägeli on New Year's Eve, 1866. In this letter he referred to Nägeli's great services to the study of hybrids occurring in nature, mentioned his own results with peas, gave an account of some new experiments he was starting with the hawksweed, and ended with what was probably the reason for his writing, an appeal for help and advice with these experiments.

Nägeli answered on February 24, 1867, addressing Mendel as Verehrtester Herr College. He recommended some hawksweed species for the proposed experiments, but the chief interest the letter has for us lies in the criticism which it contains of Mendel's well-known formulæ. Nägeli said: "Die Formeln dürften Sie wohl ebenfalls für empirische halten, da dieselben als rationellen nicht zu erweisen wären." Mendel's reply to this criticism is a little difficult to understand, and Prof. Correns remarks in a footnote, "Ich weiss nicht, ob Mendel hier das, was Nägeli unter empirischer und rationeller Formel meinte, ganz verstanden hat." But I suggest Mendel's reply becomes intelligible if we divide it into two sections (the first of which ends with the sentence to which Correns's note is appended), and regard each section as an answer to one of two interpretations, of the criticism, by Mendel, who I imagine was not quite sure what Nägeli meant. In the first part of his answer Mendel interprets the criticism as meaning that the simple formulæ, in which only one pair of characters is concerned, are "empirical," and that the complex ones, in which many are concerned, are "rational." I think we may be pretty sure that Nägeli did *not* mean this; however, I am not here concerned with what he did mean.

Nor do I stop to discuss what Nägeli may have meant when I come to consider the second section of Mendel's reply. The point is that it begins with the words "Was schliesslich die Angaben über die Verschiedenheit der von den Hybriden gebildeten Keimbläschen und Pollenzellen betrifft. . . ." Mendel is discussing an entirely different subject now, and he shows unconsciously by this fact that it never occurred to him that Nägeli might mean by his criticism that while of course it was impossible to deny the numerical proportion of the different categories (1D : 2DR : 1R), that was a very different thing from stating one's belief that the suggested interpretation of that proportion (the random union of

$$50\%D + 50\%R \text{ with } 50\%D + 50\%R)$$

was true, and that it was very desirable that these two entirely different things should not be confused. Nägeli may or may not have meant this, but the point of interest is that it did not occur to Mendel that he might have done, which shows that so far was he from confusing these two things that the possibility that he might have done never occurred to him as an interpretation of Nägeli's criticism.

I have discussed this at some length because such confusion is not rare among modern students of heredity.

This second letter of Mendel's was accompanied by several packets of peas, which were sent to set Nägeli's doubts at rest.

1 "Studies in Blood-pressure: Physiological and Clinical." By Dr. George Oliver. (London: H. K. Lewis, 1906.) Price 2s. 6*d*. net.

2 "Gregor Mendel's Briefe an Carl Nägeli, 1866–73. Ein Nachtrag zu den veröffentlichten Bastardierungsversuchen Mendels." Edited by C. Correns. Abhandl. d. K. S. Gesellsch. d. Wissensch., math.-phys. Kl. xxix. iii. Pp. 189–264. (Leipzig: B. G. Teubner, 1905.) Price 3 marks.